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## Electric Power Crisis in Nigeria: A Strategic Call for Change of Focus to Renewable Sources

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# Electric Power Crisis in Nigeria: A Strategic Call for Change of Focus to Renewable Sources

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**Abstract.** In all ramifications, the development and economic prosperity of a nation substantially depend on her power or energy sector. Reliable access to the electric power needed by several homes and businesses remains a great obstacle facing Nigeria. More than ever, the social-economic wellbeing of Nigeria is under severe threat due to formidable challenges in her Power sector. The manufacturing industries are folding up, while others are relocating their production plants to more friendly havens because of the high cost of doing business. This paper reviews various renewable energy options available to Nigeria and the National Renewable Energy and Energy Efficiency Policy (NREEEP). It also identified the major factors militating against renewable energy development in Nigeria, proffering possible way forward to assist renewable energy policy implementation.

**Keywords:** Electric power; GDP; development; NREEEP; Renewable energy

## 1. Introduction

Nigeria is the largest economy in Sub Saharan Africa, but the Nigeria economy is characterized by a continuously increasing rate of inflation, high unemployment rate, stagflation, receding stock market index and full-blown recession which is substantially due to limitations in the power sector[1]. Several years of negligence and improper policy implementation strategy has culminated into the present economic quagmire. The strong nexus between the energy and socio-economic wellbeing of a nation cannot be overemphasized. Notwithstanding her large oil and gas reserve, which compete favourably among the largest reserve in the world, Nigeria is battling with the severe energy crisis. The unpalatable effect of this situation is felt mostly by the masses that have to endure the excruciating effect of higher and arbitrary tariff including a prolonged period of power outage. Several nations who have heeded the warning of nature have diversified their power sector to eco-friendlier renewable sources and have since been reaping the dividend as revealed in their Gross Domestic Product. Electricity was first generated for public use in Nigeria in 1896 and over a century after, electricity demand in Nigeria is at present far more than the supply, thereby negatively affecting the country's socio-economic and technological developments [2, 3]. Based on the United Nation estimate as at 2017, Nigeria population is approximately 190 million [4] as against around 150million in the year 2012 [5], this is an indication of Nigeria ever-growing population. The larger part of this population lives in the rural area where there are no infrastructures for electricity supply with just around 36 % access to power [1]. In aggregate, only about 40 % of Nigerians are connected to the national grid, even those who are connected to the grid have access to power less than half of the time [6].

Nigeria's electricity consumption is one of the lowest in the world at 149 kWh per capita, about 7% of Brazil's and 3% of South Africa's [6]. Nigeria over-dependent on gas for the power plant is making



her so vulnerable, and this is perpetually leaving her at the mercy of the militant insurgents who vandalize the pipelines at will. For the second time in 2016, a case of zero generation was reported for some state in Nigeria[7]. The electricity generated in the first quarter of the year 2018 is a painful reminder of the persistently low electricity supply in Nigeria[8]. The cumulative power supply reduced to approximately 114GW as against 144GW recorded for the last quarter of the year 2017[8]. In the last 17years, several billions of dollars have been splashed on electricity power sector, yet the industry is in doldrums [7]. The reported peak electricity generation capacity of Nigeria as of February 2015 is 3342MW compared to an estimated peak demand of 12,800MW representing a power deficit of 74%[9] Despite the recent privatization of electric power generation and Distribution Company, there are no commensurate improvements in supply, rather it has gone worst. The Nigerian Electricity Regulatory Commission (NERC) website recalled that total energy at its peak in a particular that lead up to June 12 was 2,591MW, while off-peak power distributed was a paltry 1,547MW. This sort of power output cannot sustain the economy which was estimated to a Gross Domestic Product of \$568.51 billion in 2014 by World Bank[10].

The manufacturing industries are folding up, while others are relocating their plants to more business-friendly countries because of the high cost of doing business. The MAN (Manufacturers Association of Nigeria) says it spends more than ₦1.8 billion (the US \$ 11, 340 million) weekly in the running and maintenance of power generators[11, 12]. The use of these generators in the industries has resulted in high cost of production since energy consumption constitutes 40 % of the production cost. At present, the cost of production in Nigeria is nine times higher than that of China [12]. The unpalatable effect of this crisis is felt mostly by the masses that have to endure higher and arbitrary tariff coupled with the prolonged period of power outage and aching cost of living while they are left to pay for the power they never consumed. These and several other uncertainties surrounding the generation, distribution and use of electricity culminate into a phenomenon christened Electric power crisis in Nigeria. Against the backdrop of all these uncertainties, a possible change of approach and more focus on the renewable energy sources will bail the country out of this quagmire and help tame this age-long monster. Renewable Energy, RE can be defined as energy obtained from sources whose utilization does not result in the depletion of the earth's resources. The world is changing focus to renewable sources and energy efficient technologies which are more sustainable when compared to fossil fuel. Therefore, it is exigent that RE solutions be proffered to cater for Nigeria imminent industrialization. From the standpoint of sustainability, sources and challenges, several authors have discussed the renewable energy policy and options in Nigeria[13-24].Oyedepo [24] outlined the primary reasons why renewable energy is a vital and indispensable component of sustainable development. Presently, energy crisis is taking its toll on the available industries as many of them are running at high cost. Even the private homes are not excluded as so many homes do not have access to electric power. The biggest issues which have been identified as the major obstacle to the growth of power sector are ; Hostile macroeconomic forces, Weak and opaque regulatory mechanism, creditworthiness[1]. In Nigeria, the plan is underway to build a nuclear power plant, however as good as that may appear, there are hidden cost attached to coal and nuclear power; For instance, in South Africa, Eskom is currently building the Kusile coal-fired power plant, and it is estimated that the coal plant will cause damage of up to R60 billion for every year of operation. This will take the form of the costs of water pollution, human health impacts, the plant's huge water footprint, and climate change [25]. The Fukushima nuclear accident which occurred in the year 2011 is still very fresh in mind. A major 15meters tsunami disabled the power supply and abruptly ended the cooling of three Fukushima reactor, not less than 1000 people died in this incidence with several rendered homeless [26, 27].

Union of concerned scientist highlighted the merits of renewable energy as follows [10]:

- Little to no global warming emission,
- Improved public health and environment quality,
- A vast and inexhaustible energy supply,

- Job creation and other economic ripple effects,
- Reliable and resilient energy system and stable energy prices.

The renewable energy potential of Nigeria is well documented in the literature and its ability to revolutionize our power sector is not in doubt, so it is in this understanding that government has come up with different policy paper including National Renewable Energy and Energy Efficiency Policy, NREEEP, however, clear-cut implementation strategies are lacking.

## 2. Analytical Framework

In order to put the electricity issues of Nigeria in perspective and evaluate the recent trend in the development of renewable energy resources under the established implementation framework of NREEEP, the following objectives will be explored in this study as indicated in Figure 1;

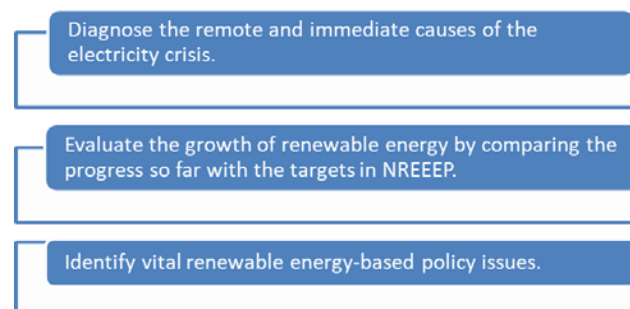


Figure 1:Analytical framework

## 3. Nigeria Electric Power Sector in Perspective

Electricity was first generated in Nigeria in the year 1896, although it was not until 1929 that the first utility company, the Nigerian Electricity Supply Company (NESCO) was established. In the 1950s and 1960s, the Nigerian government created the Electricity Corporation of Nigeria to control all existing diesel/coal fired isolated power plants across the country and the Niger Dams Authority to develop hydroelectric power in Nigeria. These two entities were amalgamated into the National Electric Power Authority (NEPA) in 1972. NEPA was characterized with a burden of subsidies, poor service quality and wretched collection of the tariff. The reform act of 2005 unbundled NEPA into 18 companies (under the flag of Power Holding Company of Nigeria): 6 generation companies, 1 transmission company, and 11 distribution companies.

The generating companies consist of three hydro and nine thermal (gas based) stations with their output shown in Figure 2 [28]. It can be observed that none of the present generating plants are made of renewable resources.

The federal government of Nigeria is seriously working towards generating 4000MW of electricity from nuclear energy, In June 2016; Nigeria signed a Memorandum of Understanding, MOU, with ROSATOM in order to partner in building a nuclear technology centre in the country. This MOU was supposed to signal the beginning of a new turn for the country to have clean energy, steady electricity supply and be able to do deep research in nuclear medicine[29]. However, these authors vehemently doubt the willingness of the government, given the inadequately trained manpower in this area combined with frightening insecurity and terrorism ravaging the country.

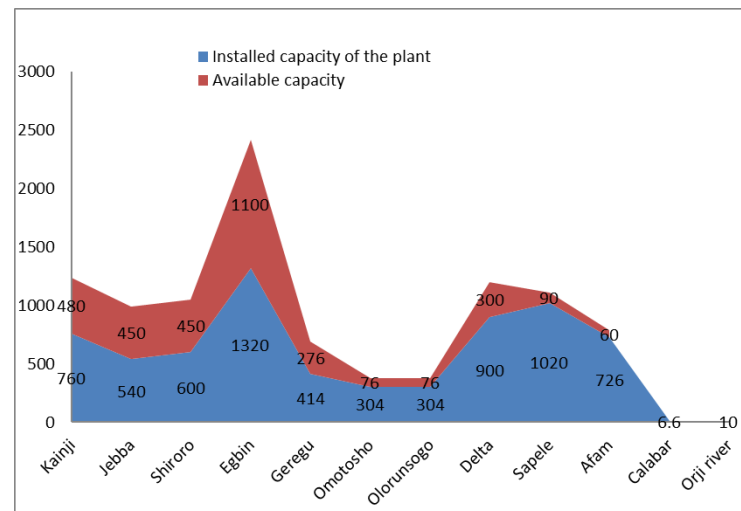


Figure 2: Nigeria power generation plant and their utilization capacity[28]

The PHCN (Power Holding Company of Nigeria) was structured to oversee the activities of the Managing Director/CEOs of the successor company for 5 years, which should be adequate to enable the companies privatized to be fully established [3]. The privatization exercise has suffered many drawbacks and its objectives have not been reasonably realized. Notwithstanding the existence of electricity in the country for over a century and in spite of all the reforms in this direction, its development has been at a slow pace. The minister of power who was part of the privatization committee in 2013 resigned from office, citing gross corruption and sabotage as his reasons for leaving the office [30].

According to Transmission Company of Nigeria (TCN), the power generation dropped to 2,662MW from initial 3,959MW as at January 2017. As usual, the reasons alluded to this include; difficulties in accessing the gas by generating company and low water level [10].

At the end of January 2016, the demand for electricity in Nigeria was estimated to be 12,800 MW [7]. Figure 3 indicates the wide margin between the energy generated and demanded over a period of three years. The historic gap between the demand for power in Nigeria and the electricity supply from the grid has led to widespread self-generation of power in the commercial, industrial and residential sectors. Many individuals and businesses own their generators to compensate for the lack of access to electricity supply [31]. Apart from the cost implication of diesel powered generator, environmental impact is also very significant [32].

A survey conducted by Adenikinju [33] showed that only 6.2 % of the firms in the Nigeria manufacturing sector exclusively rely on the grid electricity. Virtually all the firms have independent power generating set to support their activities. Figure 4 shows the contribution of power outages to capacity underutilization in the manufacturing sector. In this survey, 44 % of the firms attributed a fall of between 20 % and 49 % in their capacity underutilization to power outages. 24 % of small-scale firms lost over 50 % of their output to unstable electricity compared to 14 % and 17 % for the medium and large enterprises, respectively. Over 20million of Nigeria household are without power while around 36 % of the rural settler have access to electric power. This shows how devastating the effect of electricity unavailability has been on the country's economic survival. In order to improve current GDP growth and narrow the current electricity supply gap, market intervention, and fundamental power sector reform which is aimed at the implementation of renewable energy exploration strategies are needed.

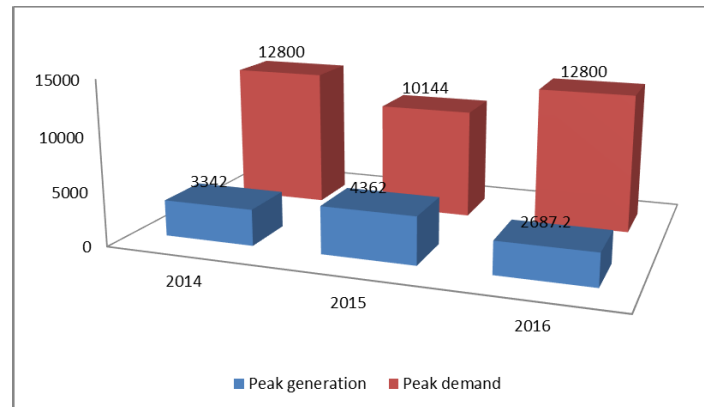
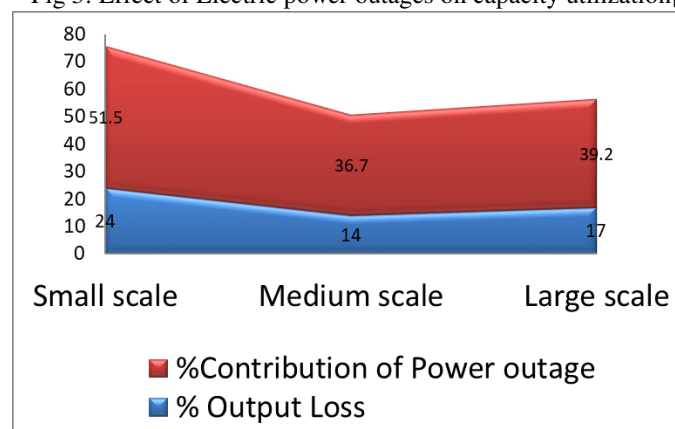


Fig 3: Effect of Electric power outages on capacity utilization[7]



**Figure 4: Effect of Electric power outages on capacity utilization. [33]**

Idemudia and Nordstrom [34] succinctly highlighted some of the challenges facing the investors that acquired Nigeria electricity assets after privatization as follows;

- Insufficient gas supply due to poor gas infrastructure,
- Cost unreflective tariff regime,
- Obsolete transmission line assets and power sub-stations,
- Non-bankable gas supply agreements,
- Changes in government and uncertainties as to the future direction of government policies,
- The bureaucracy of government agencies,
- Lack of affordable and accessible long-term funding;
- Foreign exchange and currency issues;
- Vandalism of power plants, equipment, and transmission lines.

The following key players are also identified in Nigeria's reformed power sector: The Federal Ministry of Power; National Electricity Regulatory Commission (NERC).

Nigeria Electricity Bulk Trading Plc (NBET); The Gas Aggregation Company Nigeria Limited (Gas Aggregator); Nigerian Electricity Management Services Authority; National Power Training Institute of Nigeria; Bureau of Public Enterprises National Council on Privatization; Transmission Company of Nigeria; Nigeria Electricity Liability Management Company; Nigerian Gas Company; Operator of the Nigerian Electricity Market [35, 36].

## 4. Recent Trend in Renewable Energy

### 4.1. Biomass

There is a substantial opportunity for the exploitation of several types of biomass including municipal wastes in Nigeria. Biomass is a biological substance derived from living or recently living organisms. It is often referred to as plant-based substances, whereas biomass applies to both plant and animal-based materials. Not until recently, biomass has a proven capacity for renewable electricity when compared with wind and solar. [37]. In Nigeria, some of the biomass sources have been identified as animal waste, plant waste, municipal and industrial waste, aquatic biomass, and so on [14, 24, 37, 38]. The estimated biomass resources stand at 2.01 EJ [39]. Biomass derived from the plant can serve small-scale industries, it can also be processed to produce cheap fuel like biogas. Given the pace of the development of the technologies for harvesting biomass, it can provide an increasing amount of "biopower". The identified feedstock substrates for an economically feasible biogas production include water lettuce, water hyacinth, dung, cassava leaves and processing waste, urban refuse, solid (including industrial) waste, agricultural residues and sewage [38-40]. An estimate shows that Nigeria produces about 227, 700 tons of fresh animal waste. Apart from sawdust and wood waste derivable from lumber industries, Nigeria can potentially produce up to 6.8 million m<sup>3</sup> of biogas from animal waste on a daily basis [39].

#### 4.2. Solar Energy

The main source of energy which supports life on earth and all other surface phenomena come from the sun [23]. Solar energy is applied in households for activities such as drying of clothes, and hot water for domestic use. On the commercial scale, it is used in generating electricity and driving of turbine in thermal electricity plant. The efficiency of the photovoltaic cells is estimated to be about 40%, however, with the latest discovery in nanotechnology, it is expected that the efficiency would be tremendously increased. Most recently, solar energy has been converted to heat, which is then stored in the thermal tank. Another method of using solar energy to generate electricity also used in recent times is to convert the sun's energy into heat which is then stored in thermal tanks [23, 38]. The thermal tanks contain molten salts or paraffin wax which can absorb a great amount of heat energy at the same state. The heat energy derived from this source can be used to drive electric generators.

The adoption of solar renewable technology in the country is low compared to the large potentials widely reported. Nwofe [41] outlines the high initial capital cost of solar technologies, low levels of education and awareness about the social and economic benefits associated with solar technologies, and a lack of access to solar radiation data recording stations as some of the factors limiting the utilization of solar energy in Nigeria.

Ohunakin *et al.* [23] highlight the barriers to solar energy development and application in Nigeria based on Painuly [42] as follows: technical, social, cultural and behavioral; economic and financial; institutional; and political and market distortion.

#### 4.3. Wind Energy

The energy sourced from the wind to generate electricity or another form of energy is called wind energy. The wind energy can be used to pump water and grinding grains. Previously electricity was generated from the windmill or ship sail. But this has evolved to wind turbine, which is presently used to convert the wind energy to electric power. In recent times numerous studies have been carried out to assess the wind speed characteristics and associated wind energy potentials in different locations in Nigeria. Promising attempts are being made in Sokoto Energy Research Centre (SERC) and Abubakar Tafawa Balewa University, Bauchi to develop the capability for the production of wind energy technologies [20].

#### 4.4. Geothermal Energy

Geothermal energy can be defined as heat energy generated and stored in the earth; as a result of the radioactivity and progressive heat loss from the earth's crust. The thermal energy in the form of heat reaches the surface from the crust due to the temperature differential between the planet and the surface. The temperature of the crust can be as high as 4273°C, hence heating the water and rock up to 370°C. This energy can be used for several purposes such as district and space heating, desalination, agricultural applications and most importantly to generate electricity. The world first large scale geothermal plant was built in the year 1911 [43]. Presently, United State is currently leading in geothermal energy exploration with 3450MW installed capacity and 2542MW generating capacity [44]. This form of energy is dependable with high sustainability due to enormous earth's internal heat content which is about 100 billion of the present world energy demand [43].



#### 4.5. Waves and tidal energy

Waves are produced by winds blowing across the surface of the ocean. However, because waves travel across the ocean, their arrival time at the wave power facility may be more predictable than the wind. In contrast, tidal energy is driven by the gravitational pull of the moon and sun. Tidal energy is produced through the use of tidal energy generators. These large underwater turbines are placed in areas with high tidal movements and are designed to capture the kinetic motion of the ebbing and surging of ocean tides in order to produce electricity. Tidal power has great potential for future power and electricity generation because of the massive size of the ocean [45, 46]. Tidal power has a relative advantage in that it can generate power from the incoming and outgoing tides. Like most emerging energy technologies, wave, and tidal technologies are currently more expensive than traditional generating resources; but with further experience in the field, adequate R&D funding, and proactive public policy support then the costs of wave and tidal technologies are expected to follow the same rapid decrease in price that wind energy has experienced. Wave and tidal energy resources are among the various energy resources that are available in Nigeria. But this has not been explored, because of insufficient R&D in this area.

#### 4.6. Hydro-Energy

This is energy generated from water conserved in a reservoir when a dam is constructed across flowing water like river or stream. Hydropower is generated by conversion of the potential energy of the high head water into electrical energy [14, 47]. The water which is conveyed by the penstock is made to fall on the blades of the turbine to run them by the conversion of the hydraulic energy to mechanical energy which in turn is converted into electrical energy by directly coupling the shaft of the turbine with a generator and the generator armature rotates to produce electricity [48]. Nigeria is significantly endowed with large rivers and some few natural falls. Small rivers and streams also exist within the present geographical spread of the country into eleven River Basin Authorities, some of which maintain minimum discharges all the year round. As it stands, hydropower accounts for about 29% of the total electricity supply [47]. In a study carried out by Aliyu and Elegba [19] in twelve (12) states and four (4) river basins, over 278 unexploited Small Hydropower (SHP) sites with total potentials of 734.3 MW were identified. However, Small Hydro Power potential sites exist in virtually all parts of Nigeria with an estimated total capacity of 3,500 MW. All the authors agreed that Nigeria possesses a potential renewable source of energy along with her numerous river systems [19, 24].

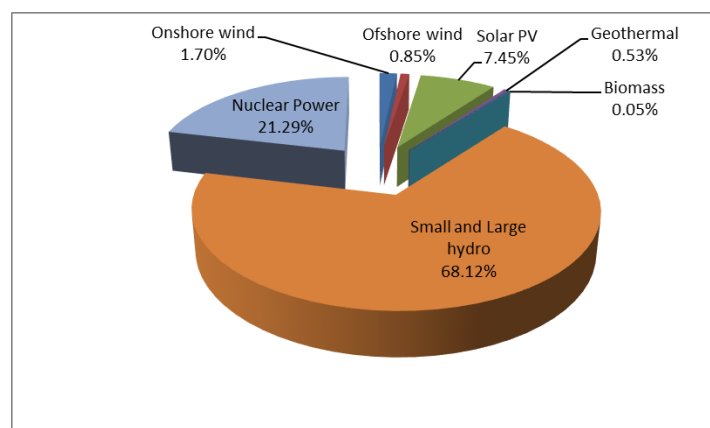


Figure 5: Renewable energy potentials of Nigeria [2, 49]

### 5. A brief review of RE in some selected Africa countries.

#### 5.1. RE South Africa



In the entire Africa continent, South Africa has the most audacious renewable energy projection. Several authors have discussed the renewable energy potential and policy in South Africa [50-53]. The 1998 Energy Policy of South Africa states that the country will acquire 15% of its national supply from RE [54]. However, an analysis of the energy mix in South Africa by Pegels [53] shows that as at 2008, coal contributed 86%, nuclear contributed 5% of the country's energy mix. Other sources are hydro and gas which combined to contribute 9% of the energy mix. [53] observed that notwithstanding the vast potential for Renewable energy in South Africa, there has so far been little growth in the deployment. The author identified energy innovation system and the economics of renewable energy technologies as the main impediment on the path of Renewable energy development in South Africa. The government of South Africa has introduced several policies to support RE in the country. One of such policies is the feed-in tariff. The renewable energy feed-in tariff was launched in 2009. It requires the national electricity utility Eskom, to purchase renewable energy from qualifying generators at predetermined prices, this help to reduce the financial risk exposure of the generators and provide the market certainty [55-57].

### 5.2. *RE Ghana*

Ghana's Renewable Energy Development Program [57, 58] aimed to assess the availability of renewable energy resources and to examine the technical feasibility and cost-effectiveness of RE technologies in the country among other goals. The program highlighted and discussed the RE potential of Ghana grouping them into two areas; biomass and solar. Wereko-Brobby and Mintah [58, 59] identified major RE projects in the country and advised on how they could be made better. Ghana has been argued to achieve commendable access to modern energy services compared to her sub-Saharan peers [59]. Increase in industrialization and urbanization have resulted in high energy intensity in Ghana, therefore, Serwaa *et al.* [60] suggested that policies aimed at encouraging the production of less energy-intensive products and implementation of high energy efficient technologies in the manufacturing sector should be promoted. Ghana's renewable energy resources could be harnessed to play a role in supplying both rural and urban households. There are huge biomass resources in Ghana that have the potential for use as feedstock for biogas production to reduce the country's overdependence on fuelwood and fossil resources. He assessed the potential of biogas in Ghana and concluded that the country has the potential of constructing about 278 000 biogas plants and as of 2011, only about 100 biogas plants have so far been constructed. The development of RE has been hampered by the failure of the government to support biogas technology through well-articulated policy, poor design and construction, horrible maintenance culture on the part of the users [61].

### 5.3. *RE Senegal*

Senegal is far ahead of Nigerian in the promotion of RE in the rural areas. Since 2008 the new Energy Sector Development Policy Paper has been in place with a clear direction for RE [62]. The policy sets a penetration rate for renewable sources of energy and biofuels of at least 15% of internal energy consumption by 2020 [63]. The commitment to institutional reform and policy has positioned Senegal as a leader in RE. Promotion in the Economic Commission of Western Africa (ECOWAS) region leading to the country being tasked to develop solar energy projects in the sub-region by Heads of State and Government in the ECOWAS Summit held in July 2010, and subsequently chosen as one of the pilot countries to field-test the methodology being developed by International Renewable Energy Agency (IRENA) for the renewable readiness assessment [62].

## 6. **Energy Mix in Nigeria**

The past and future energy mix projection Figure 5 as indicated by Obadote [2] and [49] shows gas and hydro fuels will maintain their positions as the main drivers of the electricity sector in the short and

medium term. Renewable fuels like solar, Biomass and wind are expected to play roles in sustaining the Vision 20:2020; though the full potentials are not going to be tapped.

As of 2008, the energy consumption mix in Nigeria was dominated by fuelwood (50.45%), petroleum products (41.28%) and hydroelectricity (8%) [16]. Apart from hydro, Nigeria has not profitably explored other RE sources. This argument has been assertively situated by [2, 6, 15, 23, 24] About six years after, the empirical situation in the country is at variance with Ajao *et al.* [64] assertion that replacing fossil fuel with RE is the ultimate. These authors somewhat agree with the view expressed by Agbaitoro [43] that the notion which states that replacing fossil fuel with RE is the ultimate goal in Nigeria is somewhat hasty and lacking sufficient supporting empirical evidence. Agbaitoro [43] posited that governments at different levels and the private sector had given RE considerable attention recently. However, the current level of RE implementation does not suggest that stakeholders have prioritized it.

## 7. Nreep 2015: Renewable Energy Policy in Perspective

There have been several policies on renewable energy in Nigeria which analyzed the renewable energy potential of the country and possible strategy for exploration. These include: National Energy Policy (NEP) [65-67]; Renewable Electricity Policy Guidelines (REPG) [68]; Renewable Electricity Action Programme (REAP)[69], National Economic Empowerment and Development Strategy (NEEDS)[70];Nigerian Biofuel Policy and Incentives (NBPI) [71]; Renewable Energy Master Plan (REMP) [47, 72]; and most recently approved National Renewable Energy and Energy Efficiency Policy (NREEEP), [73].

As stated in the policy document, the cardinal idea behind NREEEP is to diversify the present monotonous inefficient electric power source in Nigeria by improving the energy mix and increasing the share of renewable energy resources contribution to national utilization. The policy was tailored to align with the best renewable energy practices across the globe.

The purpose of NREEEP, [73] among other things can be summarized as follows;

- i) Set out a framework for action to address Nigerians challenge of inclusive access to modern and clean energy resources, improved energy security and climate objectives. These will also incorporate provisions for renewable energy and energy efficiency generation activities into state policy statements and plans, and recognizes the importance of enabling a framework for private investment in renewable energy and energy efficiency;
- ii) Declare that the proportion of Nigeria's electricity generated from renewable energy sources shall increase to a level that meets or exceeds the ECOWAS regional policy targets for renewable electricity generation and energy efficiency for 2020 and beyond and also set national targets for achievements in electricity from renewable energy and energy efficiency capacity addition by 2020 and beyond.
- iii) Make it mandatory for the Ministry of power to facilitate the development of an integrated resources plan (IRP) and ensure the continuous monitoring and review of the implementation and effectiveness of the action plans prescribed under the national policy statement.

This policy, having identified the resources situation and the technology of the country, focuses on hydropower, biomass, solar, wind, geothermal, wave and tidal energy power plants and cogeneration plants for energy production, as well as the improvement of energy efficiency as an additional source of energy. For each element of renewable energy, the policies, objectives, and strategies were outlined as contained in the National Energy Policy (NEP) [65]. The short-term, medium-term and long-term objectives and target were well articulated.

The overall objective of NREEEP [73] is summarized as follows:

- i. To ensure the development of the nation's energy resources, with diversified energy resources option, for the achievement of national energy security and an efficient energy delivery system with an optimal energy resource mix.

- ii. To guarantee an adequate, reliable, affordable, equitable and sustainable supply of renewable energy at cost-reflective and appropriate costs and in an environmentally friendly manner, to the various sectors of the economy, for national development.
- iii. To accelerate the process of acquisition and diffusion of technology, managerial expertise and indigenous participation in the renewable energy and energy efficiency sector industries, for stability and self-reliance.
- iv. To guarantee efficient, location-specific and cost-effective consumption pattern of renewable energy resources and improved energy efficiency.
- v. To promote increased investments and development of the renewable energy and energy efficiency sector, with substantial private sector participation.
- vi. To ensure a comprehensive, integrated and well informed renewable energy and energy efficiency sector, with plans and programs for effective development.
- vii. To foster international co-operation in trade and project development, in the ECOWAS, African Region and the World at large.
- viii. To successfully use the nation's abundant energy resources to promote international cooperation.
- ix. To bring abundant electricity access to almost half of the Nigerian population that is currently electricity abstinent, including more sustainable provisions for domestic use and cooking.
- x. To develop the nation's renewable energy and energy efficiency resources through the establishment of an appropriate financing mechanism that supports private investment in the sub-sectors.
- xi. To ensure effective coordination and collaboration

The document also summarized the implementation policies which have been applied successfully in other nations. The policy documents identify the regulation and fiscal instrument that have been applied. These can be summarized as follow;

- i) Mandatory or voluntary Renewable Portfolio Standards (RPS), which define the percentage of energy generated that must come from renewables by a given target year;
- ii) Generation Disclosure Requirement (GDR), which is applicable when consumers have a retail choice and have a preference for renewables;
- iii) Power Production Tax Credit (PTC) to electricity generation companies, which is aimed at incentivizing the adoption of renewable energy;
- iv) Feed-in tariffs (FIT), which typically incentivize electricity producers by offering more favorable pricing for electricity produced through renewables;
- v) The adoption of a Public Benefits Fund (PBF), which requires that a certain percentage of the tariff is dedicated to supporting renewable energy generation projects on and off the grid;
- vi) Bidding rounds through national renewable energy independent power producer procurement program;
- vii) Provision of capital grants, tax holidays and exemptions, other incentives for renewable energy projects;
- viii) Net metering framework.

It is observed that NREEEP policy document did not expatiate on the waves and tidal energy option despite its availability, the reason posited was that there were no sufficient Research and Development focuses on this subject. This is in line with the position of [22]. The NREEEP document projected the contribution of the RE based on 7% GDP growth over a short-term (2015), medium term (2020), and long-term (2030)[73]

These authors find the policy document very comprehensive and in line with the best practices around the globe. However, much has not been done in the area of implementation, and these authors are of the opinion that if serious attention is not focussed toward implementation, this report may go in the

way of other lofty policy papers which were not properly explored. The objectives should be to explore the relative renewable energy advantages for different state and local government [14, 20, 21]. With this, the country will be able to thoroughly analyze the area of strength of each state to tap their renewable resources. More so, this policy is capable of turning around the finances of so many states in Nigeria, which are currently battling with an insufficient allocation from the federal government.

## **8. Prospect of Renewable Energy to revolutionize Nigeria power sector: The obstacles and leverages.**

It is very obvious from the current status of RE in Nigeria that the application of RE technologies for electric power generation has been slow and not well implemented despite an explicit policy paper. Some sort of stimulatory measures were put in place to promote RE service provision in Egypt, South Africa, and Malaysia, the same measures were outlined by Shaaban and Petinrin [21]. Therefore, for a successful penetration of renewable energy in Nigeria, which is capable of bailing the country out of her present energy crisis, it is apt to evaluate different international best practices and policies for RE integration. Therefore, these authors will discuss the obstacles that must be subdued and also lend their impetus to some policy implementation strategies, regulations and legislative frameworks that can speed up the development of RE for electric power generation in Nigeria.

### *8.1. Internal and international politics and policy (IIPP)*

Internal politics of a country and its international goodwill could either serve as a stimulator or barrier to the implementation of renewable energy policy. As it is presently observed in Nigeria, the successive administrations are not always averse to continue with the policies of their predecessor, partly because of their quest to build a name for themselves. This is a counterproductive practice, which has left the country with a lot of abandoned projects. There is meant to be a continuum in government. To attain a favorable RE level, the enabling and systematic legal and regulatory framework is vital. Therefore, the progression of RE technologies demands a formidable political will via a well-articulated bureaucratic process that is void of polarity along political affiliation and personal interest. From an international perspective, economic-political risk factors play a role in determining the attitude of international associates to renewable energy implementation. Economic-political risk factors arise from the competition around scarce and valuable resources, tensions, conflicts and violence resulting from overly abundant, and the risk of the owner of a strategic resource using it as a tool for achieving a political and economic advantage. On the contrary, liberal international relations theory presents a perspective and views interdependency as an important security-building factor [74, 75]. According to this theory, the more dependent countries are on each other, the more secure the world will be, which will also bring security to individual countries. This also includes energy security.

For instance, Lilliestam and Ellenbeck [76] analyzed the potential risks to the EU from the new interdependencies arising through large-scale imports of renewable electricity from North Africa. By comparing the relative importance of stable demand for energy to the supplier and stable supply of energy for the user, those authors showed that the EU can be vulnerable to coordinated political action from the supply countries, whereas a single country has more to lose than the EU from an action restricting the supply of solar electricity. From the illustration above it is obvious that the implementation is mostly based on the prejudicial view of the stakeholders. These authors align with the position of [75] and advise that renewable energy implementation should not be undermined based on prejudice. The larger picture and the common economic interest of the countrymen should engender the implementation.

### *8.2 Financial strategy*

The initial start-up cost of renewable energy plant is always the major obstacle for the potential investors. Although the renewable energy resources have low operational and maintenance cost, the upfront capital investment is high compared to conventional energy alternatives. Another obstacle is the common perception about RE as been untested technologies. This notion has drastically reduced, thanks to the recent development in renewable energy applications. The investors are left to decide against the odds of economic risks and uncertainties. In a dwindling and recession infected economy like Nigeria, with very high demand on meager capital resources, the investor may face the high cost of the transaction and restricted access to capital. This inadequate access to financing, cum high-interest rates, culminate in the primary barriers hampering the RE market growth [13].

*a. Fiscal issues*

Fiscal incentives can be introduced to address some of the obstacles to RE development. This can be in the form of tax exception on RE equipment that is imported into the country, and a tax holiday on the RE incomes [36]. Also, the country can introduce environmental taxes, as it has proven to be very successful in Denmark. Although, this may be a gradual process in the case of Nigeria because of weak environmental policy and inadequate alternatives to fossil fuel. Denmark energy consumers have been charged a CO<sub>2</sub> tax and some of the revenue generated goes to generators of electricity from renewable energy [77]. In the Netherlands, industries received accelerated depreciation of investment in equipment when invested in renewable and energy efficiency projects [78]. Considering the environmental merits of RE, increased government support will cushion the current exorbitant capital investment requirement which is associated with RE technologies, hence encouraging the private sector to invest in RE. Fiscal and financial incentives should cut across business stages, from incorporation to production.

The fiscal support should be more in the form of production tax credit as against tax incentive on investment. This will motivate the owner to ensure the effective and efficient function of the power plant and reduce the possibility of abuse like it was previously observed in fuel importation subsidy regime and duty-free importation of goods which was severely abused for personal purposes.

*b. Legislation and Relation matters*

To achieve sufficient electric power supply where renewable play a vital role, relevant policy framework must be in place. This must include regulatory instruments which provide a conducive environment for both international and domestic investors. The legislation must be devoid of any ambiguity, hence the roles of all the stakeholders at every level of renewable energy development must be well clarified. [18].

In other countries, several legislative supports have been lent to RE development; this includes Feed-in Tariff in Germany and Brazil; Auction regime in Brazil; Quota obligation in the USA [22]. These legislative inputs have helped to position these countries in maximizing the benefit of RE.

With a proper legislation backed tendering procedure, the need for financial assistance is drastically reduced. In a situation where there is no well established tendering arrangement, subsidy arrangement presents itself as the main instrument. This has been successfully implemented as in the Swedish wind energy schemes [79]. However, such an approach must be done with a lot of caution because of Nigeria previous experience on petroleum products subsidy regime, which was thoroughly bastardized through corruption and rent taking.

*c. Research and Innovation*

The sustainability of any RE policy is contingent upon R&D Most of the previous R&D programs in Nigeria are typically in the form of grants which often do not have any expectations of the financial gain to the country. However, it is very important that funded R&D program develops patentable



technologies. And the researcher must be held to their targets as it is presently obtainable in China. Also, the government of Australia has used their competitive grant scheme christened Renewable Energy Demonstration Programs (REDP) to encourage the development of large-scale RE and mini-grid project [80]. Nigeria can also key into such R&D strategy for accelerated RE development. Proper dissemination of information is also necessary to get the citizen more acquitted with the efforts of the government in the direction of RE.

## 9. Conclusion and recommendation

These articles review the renewable energy progress in Nigeria and also make a case for a proper implementation strategy. It is very clear from the current status of RE in Nigeria that its application in electric power generation has been very slow. The policy is well articulated, but innovative strategies are urgently needed for implementation. These measures which can give meaning to different policy paper will come in form of regulations, legislative framework, licensing arrangements for private-sector operators, Feed-in Tariffs and clarifying market rules for RE services and products.

The authors have discussed some policies, regulations and legislative frameworks that can speed up the development of RE for power generation in Nigeria. Moreso, RE could be the solution to the present problem of rural electrification. And it may be a major approach to get Nigeria out of the present economic situation.

Most of the Nigeria power generating facilities are operating at low efficiency. Therefore, the present Transmission and distribution network should be technically reviewed so as to accommodate renewable energy contribution to the national grid. Grid connected to the wind, solar, biomass power project can be developed on a fast track basis which can be commissioned within 1- 2 years. This could be a quick fix for the ongoing electricity crisis and contribute to improving the revenue and fiscal stability of the country. Since the plan is already underway for the implementation of the Nuclear power plant, the government of Nigeria should be careful to ensure a transparent feasibility study and analysis which is devoid of political interference. The safety of the nuclear power plant must be carefully addressed given the volatile security situation in the country.

The Implementation issues that have been identified should be holistically addressed. The implementation progress can be fully monitored by taking advantage of the Information Technology as have been successfully tried in other countries such as Malaysia. This will engender transparency and boost the confidence of the investors. Also, comprehensive studies should be conducted to implement renewable energy in rural and non-grid-connected areas of the country. This can be done through a participatory community-based business model. An energy policy which encourages efficiency should be devised. The manufacturing standard should be developed in such a way to eliminate energy-inefficient devices from the market.

A capacity building programs for all stakeholders at all levels of governance should be implemented. This will improve the performance of different governmental agencies that have roles in renewable energy implementation. The research funding for Renewable energy should be improved and monitored so as to identify the localized solution to disseminate the use of renewable energy.

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